

Inter (Part-I) 2017

Physics	Group-I	PAPER: I
Time: 2.40 Hours	(SUBJECTIVE TYPE)	Marks: 68

SECTION-I

2. Write short answers to any EIGHT (8) questions: (16)

- (i) Does a dimensional analysis give any information on constant of proportionality that may appear in an algebraic expression? Explain.

Ans By dimensional analysis, an algebraic expression of a physical quantity can be derived but constant of proportionality cannot be determined. It can be determined by experiments.

- (ii) Suggest one method of reducing the uncertainty in any timing experiment.

Ans To find the uncertainty of a timing device's readings, divide the least count of the timing device (watch) by the total no. of vibration. In order to reduce uncertainty in this case, we increase the number of vibration.

- (iii) How many nanoseconds are in one year?

Ans 1 year = $365 \times 24 \times 3600$ s

$$1 \text{ year} = 3.15 \times 10^7 \text{ s}$$

$$\therefore 1 \text{ ns} = 10^{-9} \text{ s}$$

$$\therefore 1 \text{ s} = 10^9 \text{ ns}$$

$$\begin{aligned} 1 \text{ year} &= 3.15 \times 10^7 \times 10^9 \\ &= 3.15 \times 10^{16} \text{ ns} \end{aligned}$$

- (iv) Show that the equation $E = mc^2$ is dimensionally consistent.

Ans Data:

Given equation is $E = mc^2$

To Determine:

Equation is dimensionally consistent.

Since, $E = mc^2$

where c is velocity of light.

Dimensions of energy are that of work.

Therefore, dimensions of L.H.S. = $[E] = [ML^2T^{-2}]$

Dimensions of R.H.S. = $[mc^2] = [M(LT^{-1})^2] = [ML^2T^{-2}]$

Hence, Dimensions of LHS = dimensions of RHS

So, above equation is dimensionally correct.

(v) Name the two different conditions that could make $\vec{A}_1 \times \vec{A}_2 = \vec{0}$.

Ans Conditions:

- (i) If \vec{A}_1 is a null vector, then $\vec{A}_1 \times \vec{A}_2$ can be zero.
- (ii) If \vec{A}_2 is a null vector, then $\vec{A}_1 \times \vec{A}_2$ can be zero.

(vi) What is the moment of a force about the point lying on the axis of rotation?

Ans The moment of force about the point lying on the axis of rotation is zero because the moment arm in this case is zero.

$$\tau = Fr \quad \text{and} \quad r = 0 \text{ in this case}$$

(vii) Define position vector and resultant vector.

Ans Position Vector:

The vector which shows position of point with respect to origin (0, 0, 0). It is denoted by \vec{r} .

Position Vector $\vec{r} = x\vec{i} + y\vec{j} + z\vec{k}$ (located the point x, y, z).

Resultant Vector:

The sum of all the vectors is equal to a single vector which has the same effect as that of all the vectors to be added, is called a resultant vector.

(viii) Under what conditions a body can move with uniform acceleration?

Ans When constant force or constant torque is acting on a body, then body is said to move / rotate with uniform linear / angular acceleration.

(ix) Explain the circumstances in which the velocity \vec{v} and acceleration \vec{a} of a car:

(a) \vec{v} is zero but \vec{a} is not zero.

(b) \vec{a} is zero but \vec{v} is not zero.

Ans

(a) \vec{v} becomes zero when brakes are applied and the car comes to rest due to acceleration in opposite direction to motion. Acceleration is not zero but velocity is zero.

(b) Acceleration is zero when the car is moving on a straight road with uniform speed.

(x) Is the range of projectile same for both angles of projection of 30° and 60° ? If your answer is yes then prove it?

Ans As we know that the formula for the range of projectile is

$$R = \frac{v_i^2 \sin 2\theta}{g} \quad (1)$$

As $\sin 60^\circ = \sin 120^\circ = 0.866$, so the range in equation (1) remains same for two angles of projection 30° and 60° .

(xi) A 20 g ball hits the wall of a squash court with a constant force of 50 N. If the time of impact of the force is 0.5 sec., find the impulse?

Ans

Mass of ball = 20 g

Force = 50 N

Time of impact = 0.5 s

$$\begin{aligned}
 \text{Impulse} &= F \times \Delta t \\
 &= 50 \text{ N} \times 0.5 \text{ s} \\
 &= 25 \text{ Ns}
 \end{aligned}$$

(xii) Explain the difference between laminar flow and turbulent flow.

Ans The flow is said to be streamline or laminar, if every particle that passes a particular point, moves along exactly the same path, as followed by particles which passed that points earlier. While the irregular or unsteady flow of the fluid is called turbulent flow.

3. Write short answers to any EIGHT (8) questions: (16)

(i) When a rocket re-enters the atmosphere, its nose cone becomes very hot. Where does this energy come from?

Ans There is a large number of dust particles and water vapours present in the air. When a rocket re-enters the atmosphere, it has to face the resistance due to particles. Some K.E. of the rocket is converted into heat energy. Therefore, the cone nose of the rocket becomes very hot due to the heat energy produced by the fluid friction of atmosphere.

(ii) A 70 kg man runs up a long flight of stairs in 4.0 sec. The vertical height of stairs is 4.5 m. Calculate his power output in watts.

Ans Work done = mgh

$$\text{Power} = \frac{mgh}{t}$$

$$P = \frac{70 \text{ kg} \times 9.8 \text{ ms}^{-2} \times 4.5 \text{ m}}{4 \text{ s}}$$

$$P = 7.7 \times 10^2 \text{ W}$$

(iii) Differentiate between geyser and aquifer.

Ans Geyser:

Geyser is a hot spring, which gives out steam and hot water into the air. They are present usually in volcanic areas.

Aquifer:

It is a rock layer holding water, which allows water to percolate through it with pressure. We can get heat energy from geysers.

(iv) What is meant by INTEL SAT? At what frequencies the, INTEL SAT-IV operates?

Ans The largest satellite system is set up by 126 countries. It is called International Telecommunication Satellite Organization (INTELSAT), an INTELSAT-IV satellite. Its microwave frequencies are 4, 6, 11 and 14 GHz. It has a capacity of 30,000 two-way telephone circuits and 3 T.V. Channels.

(v) A body of mass 'm' is suspended from the ceiling of an elevator. If the elevator is ascending with an acceleration 'a', what would be the value of 'T' acting on the body?

Ans If a body of mass m is suspended from the ceiling of an elevator and it is ascending with acceleration a, the value of tension acting on the body is $T = mg + ma$

(vi) When mud flies off the tyre of a moving bicycle, in what direction does it fly?

Ans The mud will fly off tangentially along a straight line. When the tyre rotates, a centripetal force acts on the mud which is equal to the adhesive force between the tyre and mud. When the angular speed of the tyre increases, the centripetal force on the mud also increases. When this centripetal force is greater than the adhesive force, the mud leaves the tyre and flies off tangentially along a straight line due to centrifugal force which is simply the reaction of the centripetal force.

(vii) What is driven harmonic oscillator? Give example.

Ans A physical system under going forced vibrations is known as driven harmonic oscillator.

Example:

When the mass of a vibrating pendulum is struck repeatedly, then forced vibrations are produced.

(viii) Differentiate between free and forced vibrations.

Ans **Free Oscillations:**

When a body oscillates with its natural frequency without the interference of an external force, it is said to be performing free vibrations or oscillations.

Forced Oscillations:

If a freely oscillating system is forced to vibrate under an external force, then forced vibrations will be produced which are known as forced oscillations.

(ix) If a mass spring system is hung vertically and set into oscillations, why does the motion eventually stop?

Ans A damped oscillator eventually comes to rest as its mechanical energy is dissipated. Same is the case with mass hanging vertically with spring air resistance plays a vital role in dissipation of energy.

(x) What are the factors on which speed of sound in air depends?

Ans Speed of sound in air depends upon following factors:

1. Density of the medium.
2. Temperature of the medium.

(xi) Which is richer in harmonics, and why:

(a) An open organ pipe. (b) A closed organ pipe.

Ans An open ends organ pipe is richer in harmonics as compare to one end closed because number of harmonics

are even and odd in both ends open organ pipe, whereas, in a closed organ pipe only odd harmonics are available.

(xii) Is it possible for two identical waves traveling in the same direction along a string to give rise to stationary wave?

Ans No, it is not possible because two identical waves produce stationary waves only when they travel in opposite directions along the same string.

4. Write short answers to any SIX (6) questions: (12)

(i) How will you increase the fringe width in Young's double slit experiment?

Ans As we know that the expression for fringe width in Young's double slit experiment is:

$$\Delta y = \frac{\lambda L}{d}$$

Above equation indicates that by increasing wavelength of light used and separation between slits and screen and by decreasing by slits separation, we can increase the fringe width.

(ii) In Newton's ring, why are the fringes circular?

Ans The thickness of air film is zero at the point of contact, O, between the lens L, and plate P. But the thickness increases from the center to the edge of the lens. Thus, the point where the thickness of air film is constant will lie on a circle with O as center. That is why, the fringe patterns are circular.

(iii) How would you distinguish between unpolarized and plane polarized light?

Ans A light wave produced by oscillating charge consists of a periodic variation of electric field vector accompanied by the magnetic field vector at right angle to each other.

Ordinary light has components of vibration in all possible planes. Such a light is unpolarized. On the other hand, if the vibrations are confined only in one plane, the light is said to be polarized.

When unpolarized light is passed through a polaroid, the emerging light beam has all the electric vectors confined in one plane at right angles to its direction of propagation. Such light is called plane polarized light (polaroid is named as polarizer).

(iv) Write the advantages use of light as transmission carrier wave over radio-wave carriers.

Ans The advantages use of light as transmission carrier wave over radio-wave carriers are:

1. The use of light as a transmission carrier wave in fiber optics has several advantages over radio-wave carrier.
2. It has much wider bandwidth capability and immunity from electromagnetic interference.

(v) If a person was looking through a telescope at the full moon, how would the appearance of the moon be changed by covering half of the objective lens?

Ans If half of the objective lens of a telescope is covered, the moon will appear full to the person looking at it. But intensity of light depends upon the diameter of the objective lens, therefore, the intensity of the light received from the moon will decrease. Thus, its brightness is reduced by the half-covered objective lens.

(vi) Write uses of the spectrometer.

Ans A spectrometer is an optical device used to study spectra from different sources of light. With the help of a spectrometer, the deviation of light by a glass prism and the refractive index of the material of the prism can be measured quite accurately. Using a diffraction grating, the spectrometer can be employed to measure the wavelength of the light.

(vii) Does entropy of a system increase or decrease due to friction?

Ans If the work is done by friction, the work will be converted into heat. The heat produced due to the friction goes into the surrounding. No useful work can be performed by it due to the unavailability of this energy, we can say that the entropy will increase when work is done by friction. Hence, the entropy of a system increases due to friction.

(viii) A thermos flask containing milk as a system is shaken rapidly. Does the temperature of the milk rise?

Ans When milk is shaken rapidly, the kinetic energy of the molecules increases *i.e.*, the work is done on molecules. Since, K.E is proportional to the temperature, therefore, the temperature of the milk rises.

(ix) What is meant by reversible process? Give its example.

Ans **Reversible Process:**

It is the process that can be performed in the reverse direction. If heat is absorbed in the direct process, it will be given out in the reverse process. In practice, all real process are irreversible.

Examples:

The process of liquefaction and evaporation of a substance performed slowly are practically reversible. Similarly, the slow compression of a gas in a cylinder is reversible process.

SECTION-II

NOTE: Attempt any Three (3) questions.

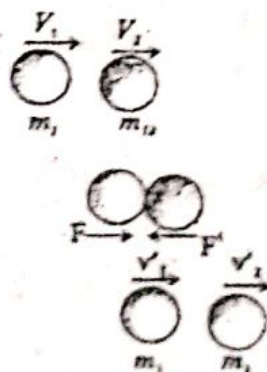
Q.5.(a) State and prove the law of conservation of linear momentum. (5)

Ans **Law of Conservation of Linear Momentum:**

In the absence of external force, the total linear momentum of an isolated system remains constant.

In an isolated system of interacting bodies, the initial momentum is equal to the final momentum. The molecules of a gas enclosed in a glass vessel at constant temperature constitute an isolated system.

Consider an isolated system of two smooth hard interacting balls of masses m_1 and m_2 , moving along the same straight line in the same direction, with the velocities \bar{v}_1 and \bar{v}_2 , respectively. After collision, the ball of m_1 moves with the velocity v_1 in the same direction as shown in the following fig. The change in momentum of mass m_1 for time interval 't' is equal to $m_1 v_1' - m_1 v_1$ and the force acting on the mass m_1 is equal to the rate of change of its momentum i.e.,



$$\bar{F} = \frac{m_1 v_1' - m_1 v_1}{t}$$

(i)

Similarly, the force acting on the mass m_2 is equal to its rate of change of momentum. i.e.,

$$F = \frac{m_2 v_2' - m_2 v_2}{t} \quad (ii)$$

As the forces acting on m_1 and m_2 are equal and opposite.

Therefore, $F = F'$

Adding (i) + (ii),

$$F + F' = \frac{m_1 v_1' - m_1 v_1}{t} + \frac{m_2 v_2' - m_2 v_2}{t}$$

$$\text{or } (F + F')t = m_1 v_1' - m_1 v_1 + m_2 v_2' - m_2 v_2$$

$$0 = m_1 v_1' - m_1 v_1 + m_2 v_2' - m_2 v_2$$

$$m_1 v_1' + m_2 v_2' = m_1 v_1 + m_2 v_2$$

Total initial momentum of the system before collision
= Total final momentum of the system after collision.

(b) Find the projection of vector $\vec{A} = 2\hat{i} - 8\hat{j} + \hat{k}$ in the direction of the vector $\vec{B} = 3\hat{i} - 4\hat{j} - 12\hat{k}$. (3)

Ans If θ is the angle between A and B, then $A \cos \theta$ is the required projection.

By definition, $A \cdot B = AB \cos \theta$

$$A \cos \theta = \frac{A \cdot B}{B} = A \cdot \hat{B}$$

Where \hat{B} is the unit vector in the direction of B.

$$\text{Now } B = \sqrt{(3)^2 + (-4)^2 + (-12)^2} = 13$$

$$\text{Therefore, } \hat{B} = \frac{(3\hat{i} - 4\hat{j} - 12\hat{k})}{13}$$

$$\begin{aligned} \text{The projection of A on B} &= (2\hat{i} - 8\hat{j} + \hat{k}) \cdot \frac{(3\hat{i} - 4\hat{j} - 12\hat{k})}{13} \\ &= \frac{(2)(3) + (-8)(-4) + 1(-12)}{13} \\ &= \frac{26}{13} = 2 \end{aligned}$$

Q.6.(a) Explain rotational kinetic energy. Find rotational kinetic energy of a disc and hoop. (5)

Ans Definition:

"The energy due to the spinning of a body about an axis is called rotational kinetic energy."

Rotational kinetic energy is given by;

$$K.E._{rot} = \frac{1}{2} I \omega^2$$

Rotational Kinetic Energy of a Disc and a Hoop:

The rotational kinetic energy of a disc is

$$K.E._{rot} = \frac{1}{2} I \omega^2$$

For a disc,

$$I = \frac{1}{2} mr^2$$

so $K.E._{rot} = \frac{1}{2} \times \frac{1}{2} mr^2 \omega^2$

therefore, $= \frac{1}{4} mr^2 \omega^2$

since $r^2 \omega^2 = v^2$

$$K.E._{rot} = \frac{1}{4} mv^2 \quad (1)$$

For a hoop, since $I = mr^2$

then $K.E._{rot} = \frac{1}{2} I \omega^2 = \frac{1}{2} mr^2 \omega^2$

$$K.E._{rot} = \frac{1}{2} mv^2 \quad (2)$$

When both starts moving down an inclined plane of height h , their motion consists of both rotational and translational motions. If no energy is lost against friction, the total kinetic energy of the disc or hoop on reaching the bottom of the incline must be equal to its potential energy at the top.

$$P.E. = K.E._{tran} = K.E._{rot}$$

$$mgh = \frac{1}{2} mv^2 + \frac{1}{2} I \omega^2 \quad (3)$$

$$\text{For disc, } mgh = \frac{1}{2}mv^2 + \frac{1}{4}mv^2$$

$$\text{or } v = \sqrt{\frac{4gh}{3}} \quad (4)$$

$$\text{and for hoop, } mgh = \frac{1}{2}mv^2 + \frac{1}{2}mv^2$$

$$\text{or } v = \sqrt{gh} \quad (5)$$

- (b) A car of mass 800 kg travelling at 54 kmh^{-1} is brought to rest in 60 meters. Find the average retarding force on the car. What has happened to original kinetic energy? (3)

Ans Data:

Mass of the car = $m = 800 \text{ kg}$

Initial velocity = $v_i = 54 \text{ km h}^{-1}$

$$= \frac{54 \times 1000}{60 \times 60} = 15 \text{ ms}^{-1}$$

Final velocity = $v_f = 0$

Distance covered by car = $d = 60 \text{ m}$

To Find:

(i) Average retarding force = $F = ?$

Formula:

$$(i) \quad v_f^2 - v_i^2 = 2ad \quad \text{and} \quad (ii) \quad F = ma$$

Calculations:

To find 'a', we use the formula, $v_f^2 - v_i^2 = 2ad$ and putting the values, we get,

$$(0)^2 - (15)^2 = 2a \times 60$$

$$\text{or } -225 = 120a$$

$$\text{Thus, } a = \frac{-225}{120} = -1.875 \text{ ms}^{-2}$$

By using Newton's second law of motion, $F = ma$ and putting the values, we get,

$$F = 800 \times (-1.875) = -1500 \text{ N}$$

Hence, $F = -1500 \text{ N}$

The negative sign indicates that the force is retarding one whose magnitude is 1500 N.

Q.7.(a) Define pressure of a gas. Prove that: (5)

$$P = \frac{2}{3} N_0 < \frac{1}{2} mv^2 >$$

Ans **Pressure of Gas:**

Pressure of gas is defined as force exerted by the gas molecules per unit area of a wall of a container.

Mathematically, $P = \frac{F}{A}$

The relation for pressure of a gas is given as:

$$P = \frac{2}{3} N_0 < \frac{1}{2} mv^2 >$$

But $N_0 = \frac{N}{V}$ = No. of molecules per unit volume

$$\therefore P = \frac{2}{3} \frac{N}{V} < \frac{1}{2} mv^2 >$$

$$\text{or } V = \frac{2}{3} \frac{N}{P} < \frac{1}{2} mv^2 > \quad (1)$$

If pressure is kept constant, $\frac{2}{3} N$ is also constant. Thus, right hand side of this equation (1) can be written as:

$$V = \text{constant} < \frac{1}{2} mv^2 >$$

$$\text{Or } V \propto < \frac{1}{2} mv^2 >$$

$$\text{Since, } < \frac{1}{2} mv^2 > \propto T \quad (\because T \propto \text{K.E.})$$

$$\therefore \boxed{V \propto T}$$

"This relation shows that volume of a gas is directly proportional to absolute temperature if the pressure is kept constant. This is known as Charles' law."

- (b) A tiny water droplet of radius 0.010 cm descends through air from a high building. Calculate its terminal velocity. Given that η for air = $19 \times 10^{-6} \text{ kgm}^{-1}\text{s}^{-1}$ and density of water $\rho = 1000 \text{ kgm}^{-3}$. (3)

Ans

$$r = 0.01 \text{ cm} = 1.0 \times 10^{-4} \text{ m}$$

as $1 \text{ cm} = 10^{-2} \text{ m}$

$$\rho = 1000 \text{ kgm}^{-3}$$

$$g = 9.8 \text{ ms}^{-2}$$

$$\eta = 19 \times 10^{-6} \text{ kgm}^{-1} \text{ s}^{-1}$$

$$V_T = ?$$

As $V_T = 2gr^2 \frac{\rho}{9\eta}$

$$V_T = \frac{2 \times 9.8 \times (1.0 \times 10^{-4})^2 \times 1000}{9 \times 19 \times 10^{-6}}$$

$$V_T = 1.96 \times 10^{-4} / 1.71 \times 10^{-4} = 1.14 \text{ ms}^{-1}$$

$$\boxed{V_T = 1.1 \text{ ms}^{-1}}$$

Q.8.(a) What are stationary waves? Describe the stationary waves produced in a stretched string and prove that their frequencies are quantized. (5)

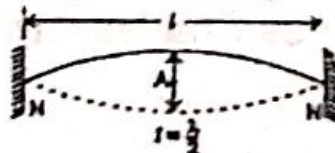
Ans **Stationary Waves:**

When two waves of equal frequency are travelling in opposite direction then stationary waves are produced.

Transverse stationary waves in a stretched string:

Consider a string of length l which is kept stretched by clamping its ends so that the tension in the string is F . Consider different cases when the string is plucked at different places.

1. First mode (Vibrating of string in one loop):



According to figure, the distance between two nodes is equal to half the wavelength (λ_1). Let λ_1 be the wavelength and f_1 be the frequency of vibration in this mode, then the length l of the string is given by:

$$l = \frac{\lambda_1}{2}$$

or $\lambda_1 = 2l$

If 'v' is the speed of the either of the component waves, then

$$v = f_1 \lambda_1$$

Putting the value of λ_1 , we have

$$v = f_1 \times 2l$$

or $f_1 = \frac{v}{2l}$ (1)

The speed of 'v' of the waves in the string depends upon the tension 'F' of the string and 'm', the mass per unit length of the string. So, the speed 'v' of the waves along the string is given by:

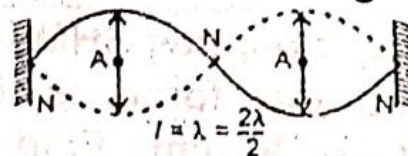
$$v = \sqrt{\frac{F}{m}}$$

Putting the value of v in equation (1), we have

$$f_1 = \frac{1}{2l} \sqrt{\frac{F}{m}}$$

This is the first mode of vibration as shown in Fig. 1. The frequency f_1 is called the fundamental frequency.

2. Second Mode (Vibration of string in 2 loops):



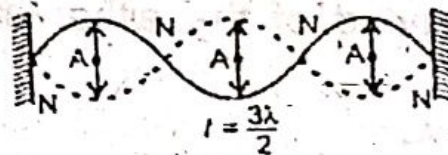
Comparing it with equation (2), we have

$$f_2 = 2f_1$$

Thus, when the string vibrates in two loops, its frequency is doubled than when it vibrates in one loop. The frequency f_2 is called second harmonic.

3. Third Mode (Vibration of string in 3 loops):

When string is plucked from one-sixth of its length, again stationary waves will be set up with four nodes and three antinodes. Now the string vibrates in three loops as shown in figure.



Let λ_3 be the wavelength and f_3 be the frequency of the waves produced. So, from figure, we have:

$$f_3 = 3f_1$$

The frequency f_3 is called third harmonic.

n^{th} mode (Vibration of string in n loops):

If the string is made to vibrate in n loops, then its frequency f_n and wavelength λ_n are given by the relations:

$$f_n = 2f_1$$

$$\lambda_n = \frac{2}{n}l$$

Fundamental frequency:

The stationary waves set up on a string have a discrete set of frequencies.

$f_2 = 2f_1$, $f_3 = 3f_1$, $f_4 = 4f_1$, ..., $f_n = nf_1$ which is known as harmonic series. The lowest of these i.e., f_1 is called the fundamental frequency which corresponds to the first harmonic.

- (b) An 8.0 kg body executes SHM with amplitude 30 cm. The restoring force is 60 N when the displacement is 30 cm. Find period and the speed when displacement is 12 cm. (3)

Ans

$$m = 8.0 \text{ kg}$$

$$\text{Amplitude} = x_0 = 30 \text{ cm} = 0.30 \text{ m}$$

$$\text{Restoring force} = F = 60 \text{ N}$$

$$\text{Displacement} = x = 12 \text{ cm} = 0.12 \text{ m}$$

Find:

$$\text{Period} = T = ?, a = ?, v = ?$$

Calculation:

(i) From Hooke's law

$$F = kx_0$$

$$K = F / x_0$$

$$K = 60 / 0.3 = 200 \text{ Nm}^{-1}$$

$$T = 2\pi \sqrt{m / k}$$

$$T = 2 \times 3.14 \sqrt{8.0 / 200}$$

$$T = 6.28 \times \sqrt{(0.04)}$$

$$T = 6.28 \times 0.2 = 1.256 \text{ sec}$$

$$\boxed{T = 1.3 \text{ sec}}$$

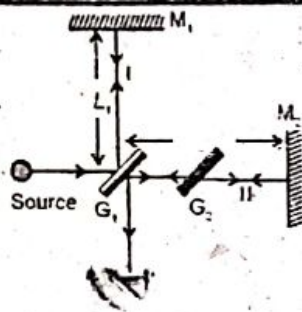
$$\begin{aligned} \text{(ii) Speed} = v &= \omega \sqrt{x_0^2 - x^2} = \frac{2\pi}{T} \sqrt{x_0^2 - x^2} \\ &= \frac{2 \times 3.14}{1.3} \sqrt{(0.3)^2 - (0.12)^2} = 1.33 \text{ ms}^{-1} \end{aligned}$$

Q.9.(a) What is Michelson's interferometer? Explain its construction and working. (5)

Ans Principle:

It splits a light beam into two parts and then recombines them to form an interference pattern after they have traveled over different paths.

Michelson's interferometer is an instrument that can be used to measure distance with extremely high precision. Albert A. Michelson devised this instrument in 1881 using the idea of interference of light rays. The essential features of a Michelson's interferometer are shown schematically in the following figure:



Monochromatic light from an extended source falls on a half-silvered glass plate G_1 that partially reflects it and partially transmits it. The reflected portion labeled as I in the figure travels a distance L_1 to mirror M_1 , which reflects the beam back towards G_1 . The half-silvered plate G_1 partially transmits this portion that finally arrives at the observer's eye. The transmitted portion of the original beam labeled as II, travels a distance L_2 to mirror M_2 which reflects the beam back towards G_1 . The beam II partially reflected by G_1 also arrive the observer's eye finally. The plate G_2 , cut from the same piece of glass as G_1 , is introduced in the path of beam II as a compensator plate. G_2 , therefore, equalizes the path length of the beams I and II in glass. The two beams having their different paths are coherent. They produce interference effects when they arrive at observer's eyes. The observer then sees a series of parallel interference fringes.

- (b) A compound microscope has lenses of focal length 1 cm and 3 cm. An object is placed 1.2 cm from the objective lens. If virtual image is formed at 25 cm from the eye, calculate the separation of lenses? (3)

Ans

Focal length of objective = $f_o = 1.0$ cm

Focal length of eye-piece = $f_e = 3.0$ cm

Distance of object from objective = $p_1 = 1.2$ cm

Distance of final image = $q_2 = -25$ cm

(Virtual image)

Find:

Separation of lenses = $L = ?$

Magnification = $M = ?$ $q_1 = ?$

Calculation:

Equation of objective lens is:

$$\frac{1}{p_1} + \frac{1}{q_1} = \frac{1}{f_o}$$

$$\frac{1}{q_1} = \frac{1}{f_o} - \frac{1}{p_1}$$

$$\frac{1}{q_1} = \frac{1}{1} - \frac{1}{1.2} = \frac{1.2 - 1}{1.2}$$

$$\frac{1}{q_1} = \frac{0.2}{1.2}$$

$$\frac{1}{q_1} = \frac{1}{6}$$

$$\boxed{q_1 = 6 \text{ cm}}$$

This image will act as an object for the eye-piece. Its distance from the eye-piece is:

$$\frac{1}{p_2} + \frac{1}{q_2} = \frac{1}{f_e}$$

$$\frac{1}{q_2} = \frac{1}{f_e} - \frac{1}{p_2}$$

$$\frac{1}{q_2} = \frac{1}{3} - \frac{1}{-25}$$

$$\frac{1}{q_2} = \frac{1}{3} + \frac{1}{25} = \frac{25 + 3}{3 \times 25}$$

$$\frac{1}{q_2} = \frac{28}{75}$$

$$p_2 = \frac{75}{28} = 2.7 \text{ cm}$$

Separation between lenses is:

$$L = q_1 + p_2$$

$$L = 6 + 2.7 = 8.7 \text{ cm}$$

We know that $d = 25 \text{ cm}$

$$\text{Magnification of objective} = M_1 = \frac{q_1}{p_1} = \frac{6}{1.2} = 5$$

$$\begin{aligned} \text{Magnification of eye-piece} = M_2 &= [1 + d/f_e] \\ &= 1 + \frac{25}{3} = 9.33 \end{aligned}$$

$$\text{Magnification of instrument} = M = M_1 \times M_2$$

$$M = 5 \times 9.33$$

$$\text{or } \boxed{M = 47}$$

